

Resource Department

## CLIMATE SCIENCE DEPARTMENT

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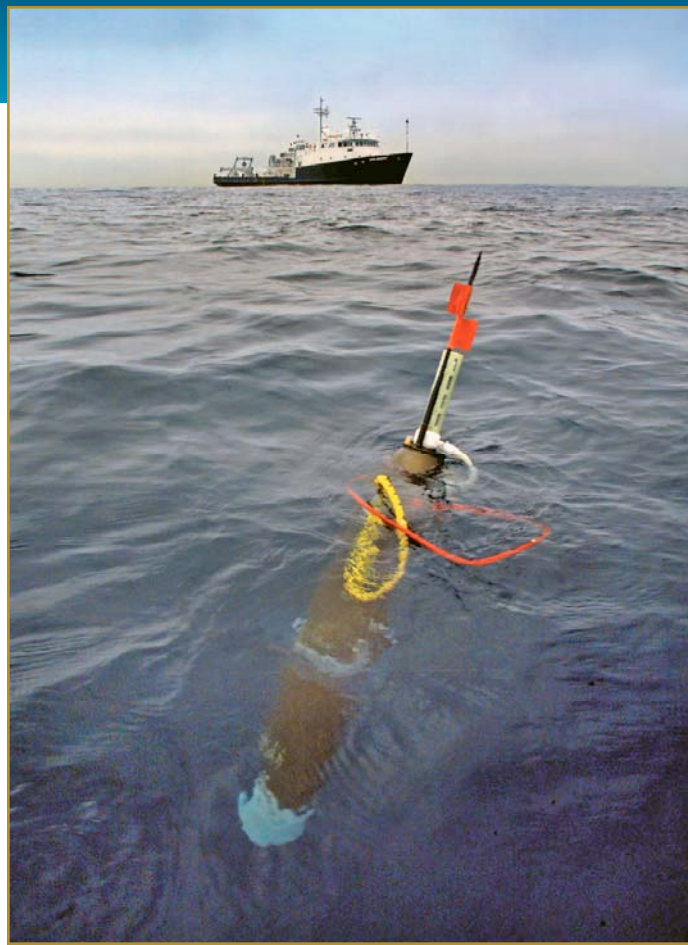
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### CLIMATE CHANGE FORCING

The goal of Berkeley Lab's terrestrial carbon research is to support the development, testing, and application of Integrated Terrestrial Carbon Models (ITCMs) that will be used to simulate carbon fluxes in North America in the near term, and coupled with global climate models in the long term. This work is a multi-institution collaboration under the coordination of the lead lab in this SFA, Oak Ridge. Berkeley Lab is pursuing five areas of research relevant to improving carbon cycle understanding: (1) better characterization of ecosystem CO<sub>2</sub> fluxes and resulting atmospheric concentrations; (2) spatially and temporally resolved measurements of fossil CO<sub>2</sub> emissions; (3) better understanding of soil carbon cycling; (4) simulation of feedbacks between carbon dynamics and climate change in global carbon-climate models; and (5) diagnosis of carbon modules in global climate models using AmeriFlux, North American Carbon Program (NACP), and other carbon system observations.

The Climate Science Department is also carrying out innovative observations of the ocean carbon cycle that would contribute to removing a major gap in coupled carbon-climate modeling. Oceans contain more carbon than any other dynamic reservoir on earth. They pose a great observational challenge because the pulses of biological productivity are episodic and cover vast areas. The Climate Science Department has developed the Carbon Explorer (see figure), an autonomous float that uses satellite telemetry to report its observations from distant oceans. Twelve of these low-cost robots have achieved the equivalent of 8 years of continuous observations of particulate organic carbon in remote and biologically dynamic ocean regions, observations that would not have been possible with conventional research ships. Seagoing work to prove and enhance new sensors for the Carbon Explorer is ongoing. The Department's new sensor for particulate inorganic carbon was operationally deployed to full ocean depth during a pole-to-pole survey transects of the Atlantic Ocean in July 2003 and January 2005. The data it reported allow the first comprehensive examination of the spatial variability of particulate organic and inorganic carbon. The Department's optical carbon sedimentation recorder was most recently deployed in Oyshio waters near Japan.



The Climate Science Department, ESD's newest department (started in April 2007), is dedicated to atmospheric and climate science. With roughly a dozen distinguished scientists, specialists, and technicians, this world-class team will lead the ESD towards the creation of a new kind of climate model, integrating cutting-edge climate science, such as the pioneering work on the carbon cycle conducted at Berkeley Lab, and drawing on work by scientists at UC Berkeley and other universities and national laboratories. The goal is not to predict climate alone, but to facilitate interactions among climate, water, and energy on a global scale. Wholly interactive, it will be able to incorporate fresh data and generate new scenarios at any point—energy demand and carbon emissions, changes in the composition of the atmosphere and the heat entering and leaving it, impacts on ecosystems and human well-being—and develop different strategies to mitigate or adapt to change.

The department's major areas of scientific focus will include climate change forcing, climate change modeling, and climate change mitigation.

## CLIMATE CHANGE MODELING

Simulations from global models provide critical information required to attribute past climate change and ameliorate future climate change. Despite the sophistication of current coupled climate models, these generally do not include the biogeochemical feedbacks, the spatial resolution, and the understanding of abrupt change required for comprehensive projections. To understand the role of these processes in regional and global climate change, the climate community should develop Earth System Models (ESMs). ESMs will be designed to simulate the coupled physical, chemical, and biogeochemical evolution of the environment. It is increasingly critical to project local extremes in precipitation and other weather conditions forced by climate change. However, these projections are subject to large uncertainties governed by model physics and model resolution. Uncertainty reduction hinges in part on site-to-regional scale process-based studies leading to new parameterizations in ESMs, analysis of model-simulated atmospheric physics and dynamics with observational evaluations, and high-resolution studies of the space-time evolution of extremes and anomalous weather and climate states. New research is needed to understand whether projections of extremes can converge with better process fidelity and higher spatial resolution.

## CLIMATE CHANGE MITIGATION

Limitations in current soil carbon models cripple scientists' ability to predict climate effects on CO<sub>2</sub> fluxes or to evaluate carbon sequestration and land management strategies. Four major gaps in the understanding of soil carbon dynamics have been identified (e.g., by BERAC, DOE, and USDA) that are important for both coupled climate-carbon modeling and carbon management, and that can be addressed in the next 5 years. Specifically, the priority areas for soil carbon research are (1) the effect of plant allocation and species on carbon residence time; (2) physical protection of soil organic matter, by minerals and aggregation; (3) temperature and moisture interactions; and (4) testing and improvement of model performance. We have in hand sufficient understanding and data to begin developing much improved model parameterizations for several of these areas.

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